CLAIMS

What is claimed is:

1. An apparatus, comprising:

a first optical waveguide disposed in a semiconductor material layer;

a second optical waveguide disposed in the semiconductor material layer; and

an insulating region disposed between the first and second optical waveguides to provide a coupling region in the semiconductor material layer between the first and second optical waveguides, the coupling region having a first coupling length for a first polarization mode of an optical beam directed through one of the first and second optical waveguides into the coupling region, the coupling region having a second coupling length for a second polarization mode of the optical beam.

2. The apparatus of claim 1 wherein the first polarization mode of the optical beam is directed out from the coupling region through the first optical waveguide and the second polarization mode of the optical beam is directed out from the coupling region through the second optical waveguide.

3. The apparatus of claim 2 wherein a wherein propagation of the optical beam through the first and second optical waveguides is bi-directional.

4. The apparatus of claim 1 wherein the semiconductor material layer includes silicon.

5. The apparatus of claim 1 wherein the insulating region includes an oxide.

6. The apparatus of claim 1 wherein the first and second optical waveguides comprise single mode optical waveguides.

7. The apparatus of claim 1 wherein said optical beam directed through said one of the first and second optical waveguides into the coupling region comprises unpolarized light.

8. The apparatus of claim 1 wherein the coupling region comprises two single mode asymmetric waveguides separated by the insulating region, the two single mode asymmetric waveguides including the first and second optical waveguides.

9. The apparatus of claim 1 further comprising modulated charge layers proximate to the insulating region in the coupling region to adjust the first and second coupling lengths.

10. The apparatus of claim 1 wherein the first polarization mode of the optical beam comprises a transverse magnetic field (TM) mode of the optical beam and the second polarization mode of the optical beam comprises a transverse electric field (TE) mode of the optical beam.

11. A method, comprising:

directing a first optical beam into a coupling region defined in a semiconductor material layer, the coupling region including an insulating region disposed between the first and second optical waveguides in the semiconductor material layer;

coupling a first polarization mode of the first optical beam from the coupling region into the first optical waveguide; and

coupling a second polarization mode of the first optical beam from the coupling region into the second optical waveguide.

12. The method of claim 11 wherein directing the first optical beam into the coupling region comprises directing unpolarized light into the coupling region.

13. The method of claim 11 further comprising:

directing a second optical beam having the first polarization mode through the first optical waveguide into the coupling region;

directing a third optical beam having the second polarization mode through the second optical waveguide into the coupling region; and

combining the first polarization mode of the second optical beam with the second polarization mode of the third optical beam into unpolarized light directed from the coupling region.

14. The method of claim 11 further comprising modulating an electric field across the insulating region disposed between the first optical waveguide and a second optical waveguide disposed in the semiconductor substrate layer to adjust a first coupling length for the first polarization mode of the optical beam directed into the coupling region and to adjust a second coupling length for the second polarization mode of the optical beam directed into the into the coupling region.

15. The method of claim 11 further comprising:

modulating the first polarization mode of the first optical beam with a first optical modulator disposed in the semiconductor material layer; and

modulating the second polarization mode of the second optical beam with a second optical modulator disposed in the semiconductor material layer.

16. The method of claim 15 further comprising combining the modulated first polarization mode of the first optical beam with the

modulated second polarization mode of the first optical beam into a modulated first optical beam.

17. The method of claim 16 wherein combining the modulated first polarization mode of the first optical beam with the modulated second polarization mode of the first optical beam into the modulated first optical beam comprises:

directing the modulated first polarization mode of the first optical beam through the first optical waveguide into a second coupling region defined in the semiconductor material layer, the second coupling region including a second insulating region disposed between the first and second optical waveguides in the semiconductor material layer;

directing the modulated second polarization mode of the first optical beam through the second optical waveguide into the second coupling region.

18. The method of claim 15 further comprising:

directing the first polarization mode of the first optical beam into a first 1x2 optical switch disposed in the semiconductor material layer;

directing the second polarization mode of the first optical beam into a second 1x2 optical switch disposed in the semiconductor material layer;

combining a first output from the first 1x2 optical switch with a first output from the second 1x2 optical switch; and

combining a second output from the first 1x2 optical switch with a second output from the second 1x2 optical switch.

19. An apparatus, comprising:

a first polarization beam splitter/combiner through which an optical beam is to be directed;

a first optical modulator coupled to the first polarization beam splitter/combiner to receive a first polarization mode of the optical beam;

a second optical modulator coupled the first polarization beam splitter/combiner to receive a second polarization mode of the optical beam; and

a second polarization beam splitter/combiner coupled to the first and second optical modulators to receive and combine modulated first and second polarization modes, respectively, of the optical beam into a modulated optical beam, the first and second polarization beam splitters and the first and second optical modulators disposed in a semiconductor material layer.

20. The apparatus of claim 19 wherein each of the first and second polarization beam splitters/combiners comprises:

a first optical waveguide disposed in the semiconductor material layer;

a second optical waveguide disposed in the semiconductor material layer; and

a insulating region disposed between the first and second optical waveguides to provide a coupling region in the semiconductor material layer between the first and second optical waveguides, the coupling region having a first coupling length for the first polarization mode of the optical beam directed through one of the first and second optical waveguides into the coupling region, the coupling region having a second coupling length for a second polarization mode of the optical beam.

21. The apparatus of claim 19 wherein each of the first and second polarization beam splitters/combiners further comprises modulated charge layers proximate to the insulating region in the coupling region to adjust the first and second coupling lengths.

22. An apparatus, comprising:

a first polarization beam splitter/combiner through which an optical beam is to be directed;

a first 1x2 optical switch coupled to the first polarization beam splitter/combiner to receive a first polarization mode of the optical beam;

a second 1x2 optical switch coupled the first polarization beam splitter/combiner to receive a second polarization mode of the optical beam;

a second polarization beam splitter/combiner coupled to a first output of the first 1x2 optical switch and coupled to a first output of the second 1x2 optical switch, the second polarization beam splitter coupled to combine

the first and second polarization modes of the optical beam received from the respective first outputs of the first and second optical switches; and

a third polarization beam splitter/combiner coupled to a second output of the first 1x2 optical switch and coupled to a second output of the second 1x2 optical switch, the third polarization beam splitter coupled to combine the first and second polarization modes of the optical beam received from the respective second outputs of the first and second optical switches, the first, second and third polarization beam splitters and the first and second 1x2 optical switches disposed in a semiconductor material layer.

23. The apparatus of claim 22 wherein each of the first, second and third polarization beam splitters/combiners comprises:

a first optical waveguide disposed in the semiconductor material layer;

a second optical waveguide disposed in the semiconductor material layer; and

a insulating region disposed between the first and second optical waveguides to provide a coupling region in the semiconductor material layer between the first and second optical waveguides, the coupling region having a first coupling length for the first polarization mode of the optical beam directed through one of the first and second optical waveguides into the coupling region, the coupling region having a second coupling length for a second polarization mode of the optical beam.

24. The apparatus of claim 23 wherein each of the first, second and third polarization beam splitters/combiners further comprises modulated charge layers proximate to the insulating region in the coupling region to adjust the first and second coupling lengths.

25. The apparatus of claim 22 wherein each of the first and second 1x2 optical switches comprises:

a Mach Zehnder interferometer (MZI) configuration coupled to receive the respective first or second polarization mode of the optical beam, the MZI configuration including first and second arms;

a phase controller in at least one arm of the MZI configuration to control a relative phase difference between the first and second arms of the MZI configuration; and

a 2x2 optical coupler coupled to the first and second arms of the MZI configuration.

26. The apparatus of claim 25 wherein the 2x2 optical coupler of each of the first and second 1x2 optical switches comprises a 2x2 multi-mode interference (MMI) device.

27. The apparatus of claim 25 wherein the 2x2 optical coupler of each of the first and second 1x2 optical switches comprises a 2x2 evanescent coupler.

28. A system, comprising:

an optical transmitter to output an optical beam;

an optical receiver coupled to receive the optical beam; and

an polarization insensitive optical modulator coupled between the optical transmitter and the optical receiver to modulate the optical beam, the polarization insensitive optical modulator including:

a first polarization beam splitter/combiner through which the optical beam is to be directed;

a first optical modulator coupled to the first polarization beam splitter/combiner to receive a first polarization mode of the optical beam;

a second optical modulator coupled the first polarization beam splitter/combiner to receive a second polarization mode of the optical beam; and

a second polarization beam splitter/combiner coupled to the first and second optical modulators to receive and combine modulated first and second polarization modes, respectively, of the optical beam into a modulated optical beam, the first and second polarization beam splitters and the first and second optical modulators disposed in a semiconductor material layer.

29. The system of claim 28 wherein each of the first and second polarization beam splitters/combiners comprise:

a first optical waveguide disposed in the semiconductor material layer;

a second optical waveguide disposed in the semiconductor material layer; and

a insulating region disposed between the first and second optical waveguides to provide a coupling region in the semiconductor material layer between the first and second optical waveguides, the coupling region having a first coupling length for the first polarization mode of the optical beam directed through one of the first and second optical waveguides into the coupling region, the coupling region having a second coupling length for a second polarization mode of the optical beam.

30. The system of claim 29 wherein each of the first and second polarization beam splitters/combiners further comprises modulated charge layers proximate to the insulating region in the coupling region to adjust the first and second coupling lengths.